TECHNICAL DESIGN CONCEPTS TO IMPROVE HELICOPTER OBSTACLE AVOIDANCE AND OPERATIONS IN "BROWNOUT" CONDITIONS

[0001] This invention claims priority to U.S. Provisional Patent Application 60/458,257 dated March 31, 2004.

Background of the Invention

Field of the Invention

[0002] This invention relates generally to flight control systems and display systems for vertical take off and landing capable aircraft.

Description of the Prior Art

[0003] Hazardous weather conditions significantly limit the operational capability of helicopters. Helicopters are called upon routinely to approach and land at remote sites without the aid of navigation guidance or acceptable and safe visual conditions. Often the topography, ground hazards, obstacles and weather in the area are unknown or changing. Upon arrival at a remote location, the pilot must make critical judgments based on incomplete or inaccurate data available to him in order to determine the proper procedure to approach and land at the site. If the surface condition is such that dust, snow, sand, etc. will be blown up by rotor downwash, the helicopter is often suddenly engulfed in a cloud of visually-restrictive material, causing the pilot to lose his visual references. The loss of visual references causes spatial disorientation problems that impede a pilot from making a fully stabilized safe landing.

[0004] The pilot uses his visual references for determining his control strategy to stabilize and bring the aircraft to a prelanding quiescent trim condition and to establish his ground closure rates as he finalizes his approach and touches down. In interviews with pilots, it was determined that pilot workload and procedures such as cross cockpit checks increase during a tactical "brownout" landing. When references are lost, a pilot may know his attitude references, but he is most likely unaware of his fore and aft, lateral, and vertical speed relative to the ground. He may also not be aware of the local terrain contour for a safe all wheel settling to the ground.

[0005] This has prevented many helicopter pilots from completing missions, or even losing control of the helicopter causing injury, and, in some cases, death and loss of the helicopter.

[0006] This limitation partially arises from the crew's inability to determine the location of obstacles in the environment by sight. In order to assist the crew in these circumstances, a range of equipment and sensors may be installed in the helicopter to provide information about the helicopter's position and the position of obstacles. The information provided by the sensors is inherently inaccurate at least because of the time delay in the system but also because of the uncertainty associated with sensor. As the dynamics of the obstacles cannot be guaranteed to be linear, these process models must be capable of reflecting this non-linear behavior. The uncertain information produced by various sensors is related to required knowledge about the obstacles by a sensor model however this relationship need not be linear, and may even have to be learned.

[0007] In order to limit the inaccuracies, current helicopter flight control systems use estimation techniques to counteract the error in the sensors. One of the best currently used techniques, an ordinary extended Kalman filter, is inadequate for estimating the uncertainty involved in the obstacles' positions for the highly non-linear processes under consideration. Neural network approaches to non-linear estimation have recently allowed process and sensor models to be learned; however, these approaches are also inadequate.

[0008] A shortcoming of the prior art is that with multiple sensors on board, there is a problem of efficiently assimilating the large amount of imagery and data available.

[0009] Additionally, another shortcoming of the prior art is the high demand that the scanning of multiple flight instruments places on a pilot. When in a brownout situation, the pilot must focus himself on multiple flight display instruments in order to compensate for his lack of visual landing references.

[0010] Yet another shortcoming of the prior art is the mechanical control of the helicopter. Currently, in contrast to modern airplanes, helicopters are either normally mechanically or hydro-mechanically controlled. The partial authority of the flight control system on such helicopters limits the ability of the flight control stability augmentation system to aid the pilot in high workload situations.